Red Snapper Fishery-Independent Index of Abundance and Age/Length Compositions in US South Atlantic Waters Based on a Chevron Video Trap Survey (2010-2019)

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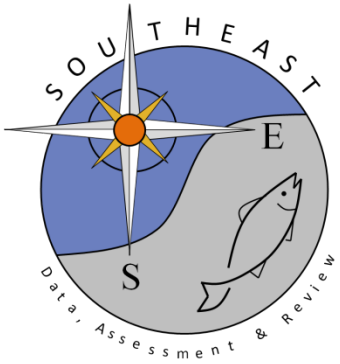

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Abstract

This report presents a summary of the fishery-independent monitoring of Red Snapper in the US South Atlantic region from three monitoring programs (MARMAP, SEAMAP-SA, and SEFIS, known collectively as SERFS). Specifically, it presents annual nominal catch per unit effort (CPUE) of Red Snapper, *Lutjanus campechanus*, in chevron video traps from 2010 to 2019. Also included are annual CPUE estimates for chevron video trap catches over this same time period that are standardized by a zero-inflated negative binomial model (ZINB) to account for the effects of potential covariates on these estimates. The ZINB model produced standardized CPUE estimates which show a generally increasing trend throughout the time series, with a slight decline in 2019, the most recent year. Corresponding age and size compositions from the video trap catches are also included.

Background

The Marine Resources Monitoring, Assessment, and Prediction program (MARMAP) has conducted fishery-independent research on reef fish species of the continental shelf and shelf edge between Cape Hatteras, North Carolina, and St. Lucie Inlet, Florida, for over 40 years. Although the MARMAP program has used various gear types and methods of deployment since its inception, starting in 1990, the chevron trap has been the primary gear deployed to allow for analyses of long-term changes in relative abundance, age compositions, length frequencies, and other information regarding reef fish species on live-bottom and/or hard-bottom habitats. In 2008, with a first field season in 2009, the Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA) provided funding to assist with the expansion of the geographical sampling coverage of the MARMAP fishery-independent chevron video trap survey. Again in 2010, with the formation of the Southeast Fishery-Independent Survey (SEFIS), additional funds were provided to, among other things, expand the geographical coverage and sampling intensity of the MARMAP fishery-independent chevron trap survey and consistently add video cameras to each trap, thus making the gear the chevron video trap. Collectively, we now refer to these three surveys' combined reef fish monitoring efforts from 2010 to present as the Southeast Reef Fish Survey (SERFS). This spatial expansion better encompassed the core geographical range of Red Snapper in the Atlantic waters off the southeastern United States compared to the earlier time period. For this reason and consistent with SEDAR41 decisions, only 2010-2019 index values are presented here, though the chevron (video) trap survey has been ongoing since 1990.

Objective

This report presents a standardized relative abundance index of Red Snapper derived from the SERFS chevron video trap survey during the years 2010-2019. The standardized index accounts for annual sampling distribution shifts with respect to covariates that affect catch of Red Snapper in chevron video traps. Also provided are annual age and length compositions of Red Snapper captured by chevron video trap. This information is critical to informing the selectivity pattern at age of Red Snapper by chevron video traps. Data presented in this report are based on the combined SERFS database accessed on October 14, 2020.

Methods

Survey Design and Gear

(see Smart et al. 2015 for full description)

Sampling area

- Cape Hatteras, NC, to St. Lucie Inlet, FL

Sampling season

- May through September
  - Limited earlier and later sampling in some years

Survey Design

- Simple random sample survey design
  - Annually, randomly selected stations from a chevron video trap universe of confirmed live-bottom and/or hard-bottom habitat stations
  - No two stations are randomly selected that are closer than 200 m from each other
    - Minimum distance is typically closer to 400 m
- Video traps deployed on suspected live-bottom and/or hard-bottom in a given year (reconnaissance) are evaluated based on catch and/or video or photographic evidence of bottom type for inclusion in the universe in subsequent years
  - If added to the known habitat universe, data from the reconnaissance deployment is included in index development

Sampling Gear – Chevron Video Traps

(see Collins 1990 and MARMAP 2009 for more detailed descriptions)

- Arrowhead shaped, with a total interior volume of 0.91 m^3
- Constructed of 35 x 35 mm square mesh plastic-coated wire with a single entrance funnel ("horse neck")
- Baited with a combination of whole or cut clupeids (*Brevoortia* or *Alosa* spp., family Clupeidae), most often *Brevoortia* spp.
  - Four whole clupeids on each of four stringers suspended within the video trap
  - Approximately 8 clupeids placed loose in the video trap
- Soak time of approximately 90 minutes
- Daylight hours

Oceanographic Data

- Hydrographic data collected via CTD during soaking of a "set" (typically 6 video traps, but may be less) of chevron video traps deployed at the same time and same reef patch
  - Bottom temperature (^oC) is defined as the temperature of the deepest recording within 5 m of the bottom

Data Filtering/Inclusion (provided to allow for reproduction of this data set from the SERFS database)

Chevron video trap data (Gear = 324) were limited to:

- Projects conducting monitoring sampling

- P05 – MARMAP
- T59 – SEAMAP-SA
- T60 – SEFIS

- Reef fish monitoring samples
  - Data source ≠ "Tag-MARMAP" – represents special historic MARMAP cruises that were used to tag various species of fish
    - Because standard sampling procedures were not consistently used (e.g. not all fish were measured for length frequency) these samples are excluded from index development
- Video traps that fished properly (i.e., appropriate catch IDs)
  - 0 – no catch
  - 1 – catch with finfish
  - 2 – catch without finfish
  - 8 - Species catch subsampled for Length Frequency
- Video traps on live-bottom and/or hard-bottom habitat (i.e., appropriate station types)
  - Random –randomly-selected live-bottom stations
  - NonRandom – non-randomly sampled live-bottom station (a.k.a haphazard or opportunistic sample)
  - ReconConv – reconnaissance deployments that were subsequently converted into live-bottom chevron video trap stations
  - Null – video traps for which there is no station code value
    - Use of station codes is fairly new, with MARMAP historically using only the catch ID (see above) to indicate randomly-selected stations
  - Monitoring - Station whose sampling selection (random, nonrandom) is not known, but is part of overall station universe
- Video traps with soak times that were neither extremely short nor long which often indicates an issue with the deployment not captured elsewhere (included 45-150 minutes)
  - SERFS targets a soak time of 90 minutes for all chevron video trap deployments
- Excluded any chevron video trap samples missing covariate information
- Excluded all video traps sampled prior to 2010

Standardized Index Model Formulation

Model Basics

- Response variable
  - Catch per video trap (i.e. CPUE)
- Offset term
  - Soak time
- Dependent variables
  - Year
  - Covariates
    - 4 covariates explored
      - Depth – Continuous variable

        - Latitude (ºN) - Continuous variable
        - Bottom temperature (ºC) - Continuous variable
        - Day of year (DOY) - Continuous variable
    - Modelled with polynomials
        - Maximum allowed polynomial order set using preliminary generalized additive models (GAMs)
            - Limited polynomial to maximum of fourth order for biological relevance
    - Due to widely differing scales, the covariates were centered and scaled
        - Centered – subtract covariate mean
        - Scaled – divided centered values by their standard deviation prior to the GAMs
- Model structure – Zero-inflated negative binomial, zero-inflated Poisson, negative binomial, and Poisson error distributions were explored
    - Mixture model for both zero-inflated error structures
    - Two parts to the model, with Bayesian Information Criteria (BIC) used to select the best model from each of the 2 zero-inflated error distributions
        - Presence/absence (binomial sub-model)
        - Catch (count sub-model)
    - Sub-models optimized using a two-step approach due to computational demands
        - Count sub-model was optimized with all covariates removed from the zero-inflation sub-model
        - Binomial sub-model was optimized using fixed count sub-model covariates obtained in previous step
        - Allows for different covariates to be included in the two sub-models
    - Bayesian Information Criteria (BIC) also used to select the best model from the negative binomial and Poisson error distribution models
    - Final model was selected amongst the best models from each of the 4 error distributions using BIC
- Annual year effect coefficients of variation (CVs) and standard errors (SE) computed using bootstrapping
    - 5,000 bootstraps
- Software used
    - R (Version 3.6.1; R Development Core Team 2019)

Age Composition

- Aging methods – sagittal otoliths were removed from Red Snapper to serve as the aging structure
    - Ages presented here are calendar age based on increment counts with an estimated increment formation on August 1 (SEDAR 41)
    - Only fish caught in chevron video traps that had age samples taken were included in the age compositions
    - Selection of fish retained for aging was complete (100% retained)

Length Composition

- All fish per video trap were measured to the nearest maximum total length (TL) in cm

Results

Sampling area

- General increase in sampling intensity (# of annual chevron video trap deployments) through time (Fig. 1)
- Chevron video trap sampling depths range from 14 to 115 m (Table 1 and Fig. 2)
  - Generally less than 100 m

Sampling season

- May through September (Table 1 and Fig. 2)

Data Filtering/Inclusion

- Included video traps (n = 13,361; Table 2)

Standardized Index Model Formulation

Model Basics

- Dependent variables
  - Covariates (Inclusion and polynomial order in sub-models available Table 3)
    - The effect on positive catches, both raw and modelled was determined (Figs. 3 and 4)
    - Depth, latitude, temperature, and day of year were included in the final model (Table 3 and Fig. 4)
- Model structure
  - Final model selected was ZINB (Table 3)
    - Selected over non-zero inflated models due to high proportion of zero counts (Fig. 5)
- Coefficients of variation (CVs) and variances stabilized within the 5,000 bootstraps (Fig. 6)
- Annual standardized and normalized (relative to the long-term mean) index values for Red Snapper, including CVs showed trends from 2010-2019 (Table 2 and Figure 7)

Age Composition

- Calendar ages caught by chevron video traps in 2010-2019 (Tables 4 and 5)

Length Composition

- Lengths presented here are TL in 10 mm bins centered around the integer
  - Meristic conversions from fork length (FL) where needed were calculated in cm using this equation developed from the SERFS database

    TL=1.079*FL+0.155, r2 = 0.999, n = 9,324 (Glasgow et al. 2020)
- Length compositions were produced for chevron video traps (Tables 6 and 7)
- All measured fish were included in the length compositions

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Table 1. Sampling summary table for the SERFS fishery-independent chevron video trap survey. Provided are the average and range of all the covariates by year.

	Depth (m)		Latitude (°N)		Temperature (°C)		Day of Year	
Year	Avg	Range	Avg	Range	Avg	Range	Avg	Range
2010	38.5	14-92	31.3	27.3-34.6	22.2	12-29.4	222	125-301
2011	40.7	14-93	30.9	27.2-34.5	21.6	15-28.8	210	140-300
2012	40.8	15-106	31.9	27.2-35.0	22.1	13-27.8	195	116-285
2013	38.2	15-110	31.3	27.2-35.0	22.1	12-28.1	197	115-278
2014	39.2	15-110	31.9	27.2-35.0	23.3	16-29.3	192	114-295
2015	39.2	16-110	31.9	27.3-35.0	22.6	14-28.4	187	112-296
2016	40.9	17-115	32.1	27.2-35.0	23.8	16-29.3	217	126-301
2017	40.5	15-114	32	27.2-35.0	22.6	15-28.2	187	117-273
2018	40.3	16-114	32	27.2-35.0	22.5	14-28.4	177	116-278
2019	40.1	16-113	32	27.2-35.0	23.3	15-29.5	185	121-269

Table 2. The annual summary of data informative to index development and the results of the standardization. The data includes number of collections included in index development, the number of positive collections for Red Snapper, the proportion of those positive collections in relation to the included collections, and the total number of Red Snapper caught. The results show the normalized nominal and standardized chevron video trap catch per unit effort (CPUE) of Red Snapper from the SERFS fishery-independent chevron video trap survey which meet criteria to be included in the standardization process. The zero-inflated negative binomial (ZINB) standardized catch also includes a coefficient of variation (CV) calculated from a bootstrapping procedure.

					Nominal CPUE	ZINB Standardized CPUE	
Year	Included Collections	Positive	Proportion Positive	Total Fish	Normalized	Normalized	CV
2010	737	65	0.09	152	0.35	0.31	0.2
2011	731	67	0.09	118	0.28	0.32	0.18
2012	1174	145	0.12	410	0.6	0.56	0.14
2013	1360	140	0.1	367	0.46	0.45	0.15
2014	1472	150	0.1	614	0.71	0.76	0.13
2015	1463	159	0.11	905	1.06	1.1	0.13
2016	1484	213	0.14	1075	1.24	1.42	0.11
2017	1541	245	0.16	1499	1.67	1.59	0.1
2018	1736	275	0.16	1925	1.9	2.02	0.1
2019	1663	287	0.17	1675	1.73	1.48	0.09

Table 3. Model error structure comparison, including covariates that were included and their polynomial level for both the count and binomial sub-models. Polynomial values of "0" indicate that the covariate was not included in the final model. Negative binomial and Poisson models only had the count sub-model. The best-fit model (highlighted) was chosen based on Bayesian Information Criteria (BIC).

	Count Sub-model					Binomial Sub-model				
Model Error Structure	**Year**	**Lat**	**Depth**	**Temp**	**DOY**	**Lat**	**Depth**	**Temp**	**DOY**	**BIC**
Zero-Inflated Negative Binomial	1	4	4	1	1	4	4	0	0	16205
Negative Binomial	1	4	4	1	1	—	—	—	—	16874
Zero-Inflated Poisson	1	4	2	3	2	4	4	1	1	24860
Poisson	1	4	4	3	4	—	—	—	—	40757

Table 4. Annual age composition by calendar age of Red Snapper caught in the SERFS fishery-independent chevron video trap survey. This value is in numbers of fish per age bin from 2010 to 2019. Total fish caught and video trap deployments with aged fish are summarized by year.

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0	0	0	0	0	1	2	0	0	0
1	1	3	16	65	86	279	56	214	87	164
2	11	3	134	86	251	374	279	250	519	588
3	88	10	89	74	135	140	526	446	901	708
4	41	72	16	26	46	22	134	358	193	185
5	20	19	91	23	10	12	21	103	112	69
6	2	9	34	31	16	3	5	36	51	48
7	0	1	18	35	23	4	4	13	21	16
8	0	0	4	11	25	20	5	7	9	2
9	1	0	2	2	15	27	12	4	4	3
10	0	1	1	1	1	28	14	15	0	3
11	0	0	0	1	1	7	5	17	2	3
12	2	0	0	3	3	0	5	16	10	6
13	0	0	3	1	0	1	0	8	15	8
14	0	0	1	2	1	1	0	0	7	10
15	0	0	1	1	1	1	1	0	0	3
16	0	0	1	2	0	4	1	1	0	1
17	0	0	1	0	0	4	0	0	0	0
18	0	0	0	0	0	0	0	2	0	1
19	0	0	2	0	1	1	0	0	0	1
20	0	0	0	0	0	0	0	0	1	0
21	0	1	1	0	0	0	0	0	1	0
22	0	0	0	0	0	0	0	0	0	1
23	0	0	0	0	0	0	0	0	0	0
25	0	0	1	1	0	0	0	0	0	0
26	0	0	0	1	0	0	0	0	0	0
Deployments	**73**	**70**	**148**	**138**	**150**	**164**	**214**	**242**	**276**	**290**
Fish	**166**	**119**	**416**	**366**	**615**	**929**	**1070**	**1490**	**1933**	**1820**

Table 5. Annual age composition by calendar age of Red Snapper caught in the SERFS fishery-independent chevron video trap survey. This value is in percentage of fish per age bin annually from 2010 to 2019. Total fish caught and video trap deployments with aged fish are summarized by year.

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0	0.00	0.00	0.00	0.00	0.00	0.11	0.19	0.00	0.00	0.00
1	0.60	2.52	3.85	17.76	13.98	30.03	5.23	14.36	4.50	9.01
2	6.63	2.52	32.21	23.50	40.81	40.26	26.07	16.78	26.85	32.31
3	53.01	8.40	21.39	20.22	21.95	15.07	49.16	29.93	46.61	38.90
4	24.70	60.50	3.85	7.10	7.48	2.37	12.52	24.03	9.98	10.16
5	12.05	15.97	21.88	6.28	1.63	1.29	1.96	6.91	5.79	3.79
6	1.20	7.56	8.17	8.47	2.60	0.32	0.47	2.42	2.64	2.64
7	0.00	0.84	4.33	9.56	3.74	0.43	0.37	0.87	1.09	0.88
8	0.00	0.00	0.96	3.01	4.07	2.15	0.47	0.47	0.47	0.11
9	0.60	0.00	0.48	0.55	2.44	2.91	1.12	0.27	0.21	0.16
10	0.00	0.84	0.24	0.27	0.16	3.01	1.31	1.01	0.00	0.16
11	0.00	0.00	0.00	0.27	0.16	0.75	0.47	1.14	0.10	0.16
12	1.20	0.00	0.00	0.82	0.49	0.00	0.47	1.07	0.52	0.33
13	0.00	0.00	0.72	0.27	0.00	0.11	0.00	0.54	0.78	0.44
14	0.00	0.00	0.24	0.55	0.16	0.11	0.00	0.00	0.36	0.55
15	0.00	0.00	0.24	0.27	0.16	0.11	0.09	0.00	0.00	0.16
16	0.00	0.00	0.24	0.55	0.00	0.43	0.09	0.07	0.00	0.05
17	0.00	0.00	0.24	0.00	0.00	0.43	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.05
19	0.00	0.00	0.48	0.00	0.16	0.11	0.00	0.00	0.00	0.05
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
21	0.00	0.84	0.24	0.00	0.00	0.00	0.00	0.00	0.05	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	0.00	0.00	0.24	0.27	0.00	0.00	0.00	0.00	0.00	0.00
26	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Deployments	**73**	**70**	**148**	**138**	**150**	**164**	**214**	**242**	**276**	**290**
Fish	**166**	**119**	**416**	**366**	**615**	**929**	**1070**	**1490**	**1933**	**1820**

Table 6. Annual length composition in maximum total length (TL) of Red Snapper caught in the SERFS fishery-independent chevron video video trap survey by centered cm bins. This value is in numbers of fish per TL bin annually from 2010 to 2019. Total fish caught and video trap deployments with measured fish are summarized by year.

TL (cm)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
16	0	0	0	0	0	1	0	0	0	1
17	0	0	0	0	0	0	0	0	2	1
18	0	0	0	0	0	0	1	0	2	0
19	0	0	0	0	1	2	1	0	5	4
20	0	0	0	0	1	8	0	1	5	9
21	0	0	0	0	0	13	0	1	12	6
22	0	0	2	1	0	22	0	3	9	9
23	0	1	2	0	2	11	3	8	6	13
24	1	1	3	3	10	12	2	17	14	30
25	0	1	6	6	5	21	0	18	11	30
26	0	0	16	3	7	21	3	21	10	59
27	0	0	12	3	6	27	10	41	9	63
28	0	0	11	5	7	34	10	32	16	90
29	0	1	10	6	6	25	11	40	23	109
30	0	1	6	7	6	26	21	43	21	89
31	1	0	3	6	7	33	26	44	43	100
32	0	1	6	8	12	17	17	49	52	71
33	0	0	11	13	13	22	11	45	81	66
34	2	0	4	15	14	39	13	43	124	60
35	0	0	8	20	17	36	16	29	127	65
36	0	0	14	16	20	26	15	40	139	52
37	1	1	15	13	33	38	30	47	142	52
38	2	0	15	9	27	40	47	35	124	50
39	0	0	20	5	33	50	57	41	141	44
40	1	0	19	7	44	25	47	35	103	40
41	5	1	14	15	49	28	54	24	100	29
42	3	0	8	7	44	22	52	30	63	27
43	11	0	9	6	41	26	68	20	53	32
44	9	2	13	3	27	13	53	43	53	34
45	8	5	7	8	20	9	50	41	27	37
46	10	0	4	6	9	18	56	47	28	37
47	4	5	5	6	17	18	45	44	17	53
48	6	3	3	8	12	19	33	50	15	36
49	8	5	1	8	5	10	33	39	12	34
50	11	4	2	6	4	15	29	47	21	42
51	0	0	1	8	2	18	23	37	22	41
52	11	2	0	3	6	9	23	25	12	26
53	11	5	0	2	0	10	21	30	13	20
54	9	8	1	2	1	13	19	25	16	23
55	3	5	3	5	1	10	17	33	17	20
56	5	4	3	1	2	11	14	38	14	11
57	7	8	2	1	2	4	14	29	20	5
58	4	7	0	2	3	5	8	28	14	3
59	5	3	4	2	2	2	9	19	12	10

TL (cm)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
60	4	7	2	1	5	2	11	21	11	7
61	2	5	7	4	1	3	7	15	14	9
62	6	3	10	3	3	3	5	12	14	10
63	0	2	6	2	1	1	5	13	16	16
64	3	3	9	7	0	2	6	11	14	7
65	3	3	7	1	1	3	3	10	9	11
66	2	2	6	1	2	3	6	11	13	10
67	0	0	6	0	3	3	3	4	11	12
68	1	3	3	1	2	3	5	6	9	11
69	0	1	14	6	3	2	3	10	8	7
70	2	4	15	2	1	1	2	7	12	6
71	1	1	8	9	1	3	1	6	14	12
72	4	1	5	4	4	6	2	1	3	7
73	2	1	12	10	6	3	2	6	5	3
74	0	2	2	5	1	4	5	5	6	6
75	1	1	6	7	6	4	1	1	3	3
76	1	1	8	12	9	7	4	6	3	7
77	1	0	4	10	6	3	3	5	6	8
78	0	3	8	5	7	12	6	5	7	8
79	0	1	3	8	17	7	7	8	3	3
80	0	0	4	6	4	14	7	8	4	5
81	0	1	4	2	8	10	5	13	5	6
82	0	0	3	7	4	5	1	6	3	6
83	0	1	2	5	1	7	2	7	4	3
84	0	0	0	1	3	6	3	7	5	5
85	0	0	1	0	4	6	4	6	4	4
86	0	1	3	3	1	3	2	2	3	1
87	0	0	1	3	3	2	1	1	1	1
88	0	0	3	3	0	0	1	2	1	3
89	0	0	1	2	0	1	0	1	0	0
90	0	0	2	0	0	0	0	0	0	0
91	2	0	0	1	1	2	0	1	0	0
92	0	0	1	0	0	1	1	0	0	0
98	0	0	0	0	0	0	0	0	1	0
99	0	0	1	0	0	0	0	0	0	0
105	0	0	0	0	0	0	0	0	1	0
Deployments	**74**	**70**	**155**	**143**	**151**	**163**	**214**	**245**	**278**	**292**
Fish	**173**	**121**	**430**	**376**	**626**	**941**	**1076**	**1499**	**1963**	**1830**

Table 7. Annual length composition in maximum total length (TL) of Red Snapper caught in the SERFS fishery-independent chevron video trap survey by centered cm bins. This value is in percentage of fish per TL bin annually from 2010 to 2019. Total number of fish caught and chevron trap deployments with measured fish are summarized by year.

TL (cm)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
16	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.05
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.05
18	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.10	0.00
19	0.00	0.00	0.00	0.00	0.16	0.21	0.09	0.00	0.25	0.22
20	0.00	0.00	0.00	0.00	0.16	0.85	0.00	0.07	0.25	0.49
21	0.00	0.00	0.00	0.00	0.00	1.38	0.00	0.07	0.61	0.33
22	0.00	0.00	0.47	0.27	0.00	2.34	0.00	0.20	0.46	0.49
23	0.00	0.83	0.47	0.00	0.32	1.17	0.28	0.53	0.31	0.71
24	0.58	0.83	0.70	0.80	1.60	1.28	0.19	1.13	0.71	1.64
25	0.00	0.83	1.40	1.60	0.80	2.23	0.00	1.20	0.56	1.64
26	0.00	0.00	3.72	0.80	1.12	2.23	0.28	1.40	0.51	3.22
27	0.00	0.00	2.79	0.80	0.96	2.87	0.93	2.74	0.46	3.44
28	0.00	0.00	2.56	1.33	1.12	3.61	0.93	2.13	0.82	4.92
29	0.00	0.83	2.33	1.60	0.96	2.66	1.02	2.67	1.17	5.96
30	0.00	0.83	1.40	1.86	0.96	2.76	1.95	2.87	1.07	4.86
31	0.58	0.00	0.70	1.60	1.12	3.51	2.42	2.94	2.19	5.46
32	0.00	0.83	1.40	2.13	1.92	1.81	1.58	3.27	2.65	3.88
33	0.00	0.00	2.56	3.46	2.08	2.34	1.02	3.00	4.13	3.61
34	1.16	0.00	0.93	3.99	2.24	4.14	1.21	2.87	6.32	3.28
35	0.00	0.00	1.86	5.32	2.72	3.83	1.49	1.93	6.47	3.55
36	0.00	0.00	3.26	4.26	3.19	2.76	1.39	2.67	7.08	2.84
37	0.58	0.83	3.49	3.46	5.27	4.04	2.79	3.14	7.23	2.84
38	1.16	0.00	3.49	2.39	4.31	4.25	4.37	2.33	6.32	2.73
39	0.00	0.00	4.65	1.33	5.27	5.31	5.30	2.74	7.18	2.40
40	0.58	0.00	4.42	1.86	7.03	2.66	4.37	2.33	5.25	2.19
41	2.89	0.83	3.26	3.99	7.83	2.98	5.02	1.60	5.09	1.58
42	1.73	0.00	1.86	1.86	7.03	2.34	4.83	2.00	3.21	1.48
43	6.36	0.00	2.09	1.60	6.55	2.76	6.32	1.33	2.70	1.75
44	5.20	1.65	3.02	0.80	4.31	1.38	4.93	2.87	2.70	1.86
45	4.62	4.13	1.63	2.13	3.19	0.96	4.65	2.74	1.38	2.02
46	5.78	0.00	0.93	1.60	1.44	1.91	5.20	3.14	1.43	2.02
47	2.31	4.13	1.16	1.60	2.72	1.91	4.18	2.94	0.87	2.90
48	3.47	2.48	0.70	2.13	1.92	2.02	3.07	3.34	0.76	1.97
49	4.62	4.13	0.23	2.13	0.80	1.06	3.07	2.60	0.61	1.86
50	6.36	3.31	0.47	1.60	0.64	1.59	2.70	3.14	1.07	2.30
51	0.00	0.00	0.23	2.13	0.32	1.91	2.14	2.47	1.12	2.24
52	6.36	1.65	0.00	0.80	0.96	0.96	2.14	1.67	0.61	1.42
53	6.36	4.13	0.00	0.53	0.00	1.06	1.95	2.00	0.66	1.09
54	5.20	6.61	0.23	0.53	0.16	1.38	1.77	1.67	0.82	1.26
55	1.73	4.13	0.70	1.33	0.16	1.06	1.58	2.20	0.87	1.09

TL (cm)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
56	2.89	3.31	0.70	0.27	0.32	1.17	1.30	2.54	0.71	0.60
57	4.05	6.61	0.47	0.27	0.32	0.43	1.30	1.93	1.02	0.27
58	2.31	5.79	0.00	0.53	0.48	0.53	0.74	1.87	0.71	0.16
59	2.89	2.48	0.93	0.53	0.32	0.21	0.84	1.27	0.61	0.55
60	2.31	5.79	0.47	0.27	0.80	0.21	1.02	1.40	0.56	0.38
61	1.16	4.13	1.63	1.06	0.16	0.32	0.65	1.00	0.71	0.49
62	3.47	2.48	2.33	0.80	0.48	0.32	0.46	0.80	0.71	0.55
63	0.00	1.65	1.40	0.53	0.16	0.11	0.46	0.87	0.82	0.87
64	1.73	2.48	2.09	1.86	0.00	0.21	0.56	0.73	0.71	0.38
65	1.73	2.48	1.63	0.27	0.16	0.32	0.28	0.67	0.46	0.60
66	1.16	1.65	1.40	0.27	0.32	0.32	0.56	0.73	0.66	0.55
67	0.00	0.00	1.40	0.00	0.48	0.32	0.28	0.27	0.56	0.66
68	0.58	2.48	0.70	0.27	0.32	0.32	0.46	0.40	0.46	0.60
69	0.00	0.83	3.26	1.60	0.48	0.21	0.28	0.67	0.41	0.38
70	1.16	3.31	3.49	0.53	0.16	0.11	0.19	0.47	0.61	0.33
71	0.58	0.83	1.86	2.39	0.16	0.32	0.09	0.40	0.71	0.66
72	2.31	0.83	1.16	1.06	0.64	0.64	0.19	0.07	0.15	0.38
73	1.16	0.83	2.79	2.66	0.96	0.32	0.19	0.40	0.25	0.16
74	0.00	1.65	0.47	1.33	0.16	0.43	0.46	0.33	0.31	0.33
75	0.58	0.83	1.40	1.86	0.96	0.43	0.09	0.07	0.15	0.16
76	0.58	0.83	1.86	3.19	1.44	0.74	0.37	0.40	0.15	0.38
77	0.58	0.00	0.93	2.66	0.96	0.32	0.28	0.33	0.31	0.44
78	0.00	2.48	1.86	1.33	1.12	1.28	0.56	0.33	0.36	0.44
79	0.00	0.83	0.70	2.13	2.72	0.74	0.65	0.53	0.15	0.16
80	0.00	0.00	0.93	1.60	0.64	1.49	0.65	0.53	0.20	0.27
81	0.00	0.83	0.93	0.53	1.28	1.06	0.46	0.87	0.25	0.33
82	0.00	0.00	0.70	1.86	0.64	0.53	0.09	0.40	0.15	0.33
83	0.00	0.83	0.47	1.33	0.16	0.74	0.19	0.47	0.20	0.16
84	0.00	0.00	0.00	0.27	0.48	0.64	0.28	0.47	0.25	0.27
85	0.00	0.00	0.23	0.00	0.64	0.64	0.37	0.40	0.20	0.22
86	0.00	0.83	0.70	0.80	0.16	0.32	0.19	0.13	0.15	0.05
87	0.00	0.00	0.23	0.80	0.48	0.21	0.09	0.07	0.05	0.05
88	0.00	0.00	0.70	0.80	0.00	0.00	0.09	0.13	0.05	0.16
89	0.00	0.00	0.23	0.53	0.00	0.11	0.00	0.07	0.00	0.00
90	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
91	1.16	0.00	0.00	0.27	0.16	0.21	0.00	0.07	0.00	0.00
92	0.00	0.00	0.23	0.00	0.00	0.11	0.09	0.00	0.00	0.00
98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
99	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
Deployments	**74**	**70**	**155**	**143**	**151**	**163**	**214**	**245**	**278**	**292**
Fish	**173**	**121**	**430**	**376**	**626**	**941**	**1076**	**1499**	**1963**	**1830**

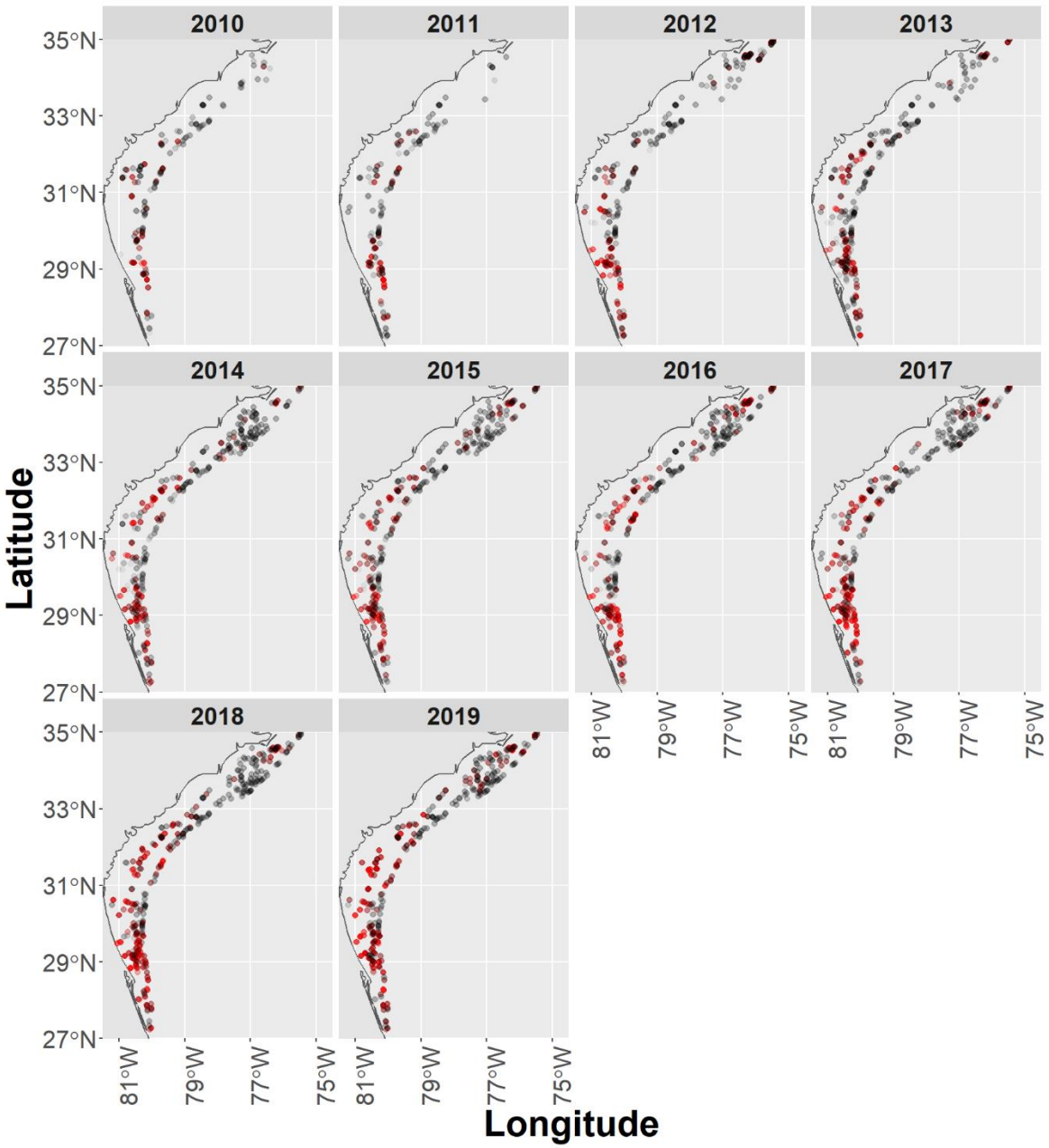

Figure 1. Sampling distribution of all collections by year of the SERFS fishery-independent chevron video trap survey. Red circles indicate positive collections for Red Snapper, while black circles represent no catch of Red Snapper.

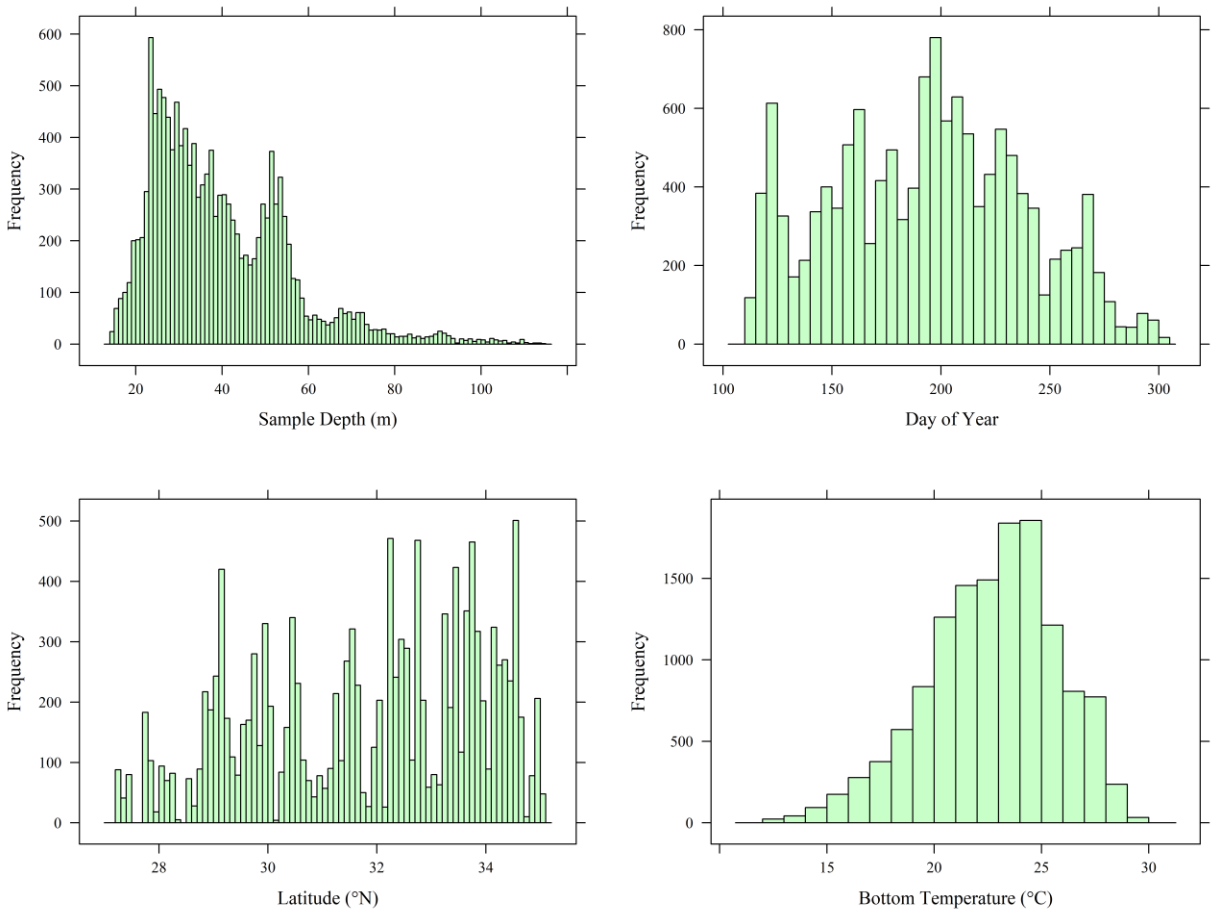

Figure 2. Sample distribution of covariate data from SERFS fishery-independent chevron video trap survey collections for depth (A), day of year (B), latitude (C), and bottom temperature (D).

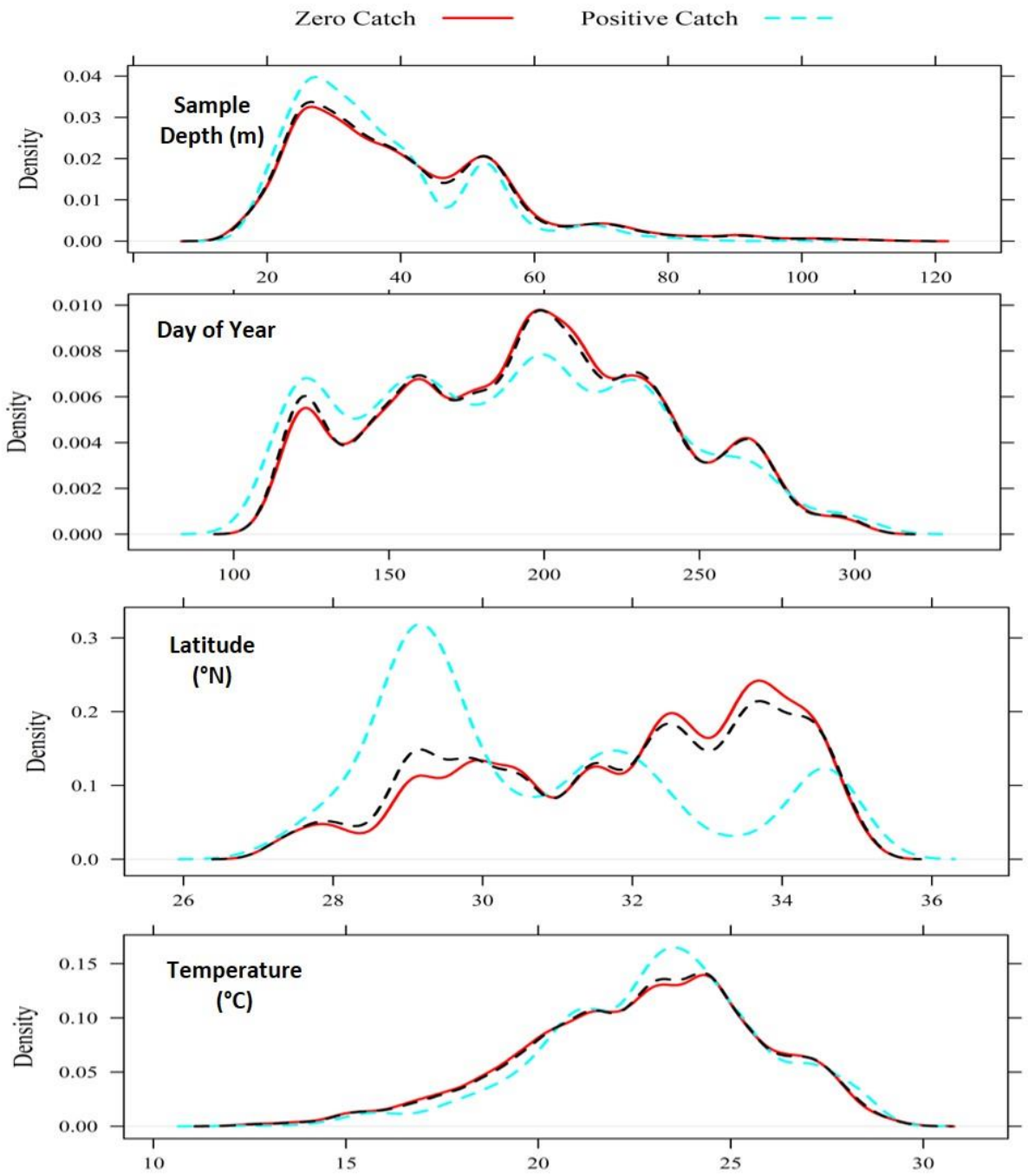

Figure 3. Sample distribution of catch of Red Snapper and effects by covariate on positive and zero catches relative to all included sampling (black dashed line).

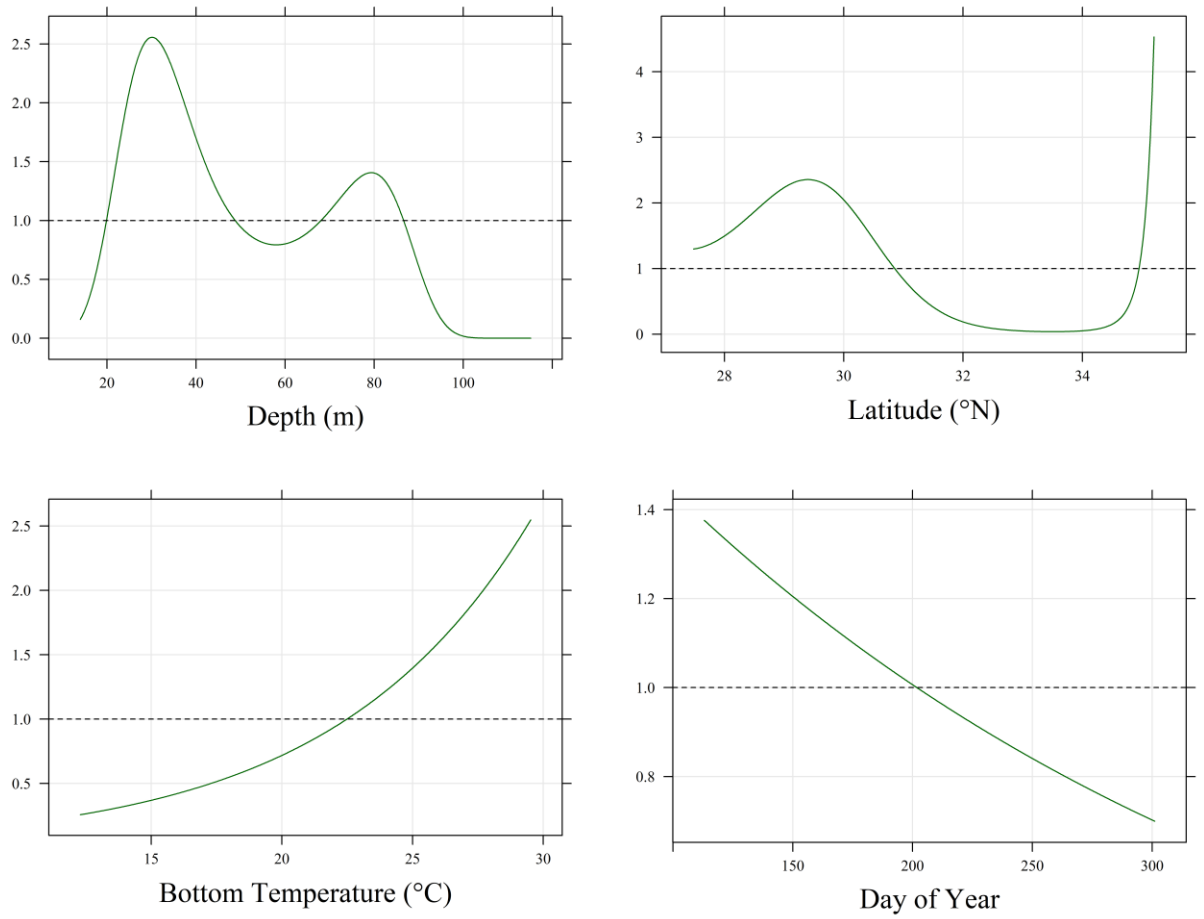

Figure 4. Modelled final covariate effects on catch of Red Snapper from the ZINB standardization.

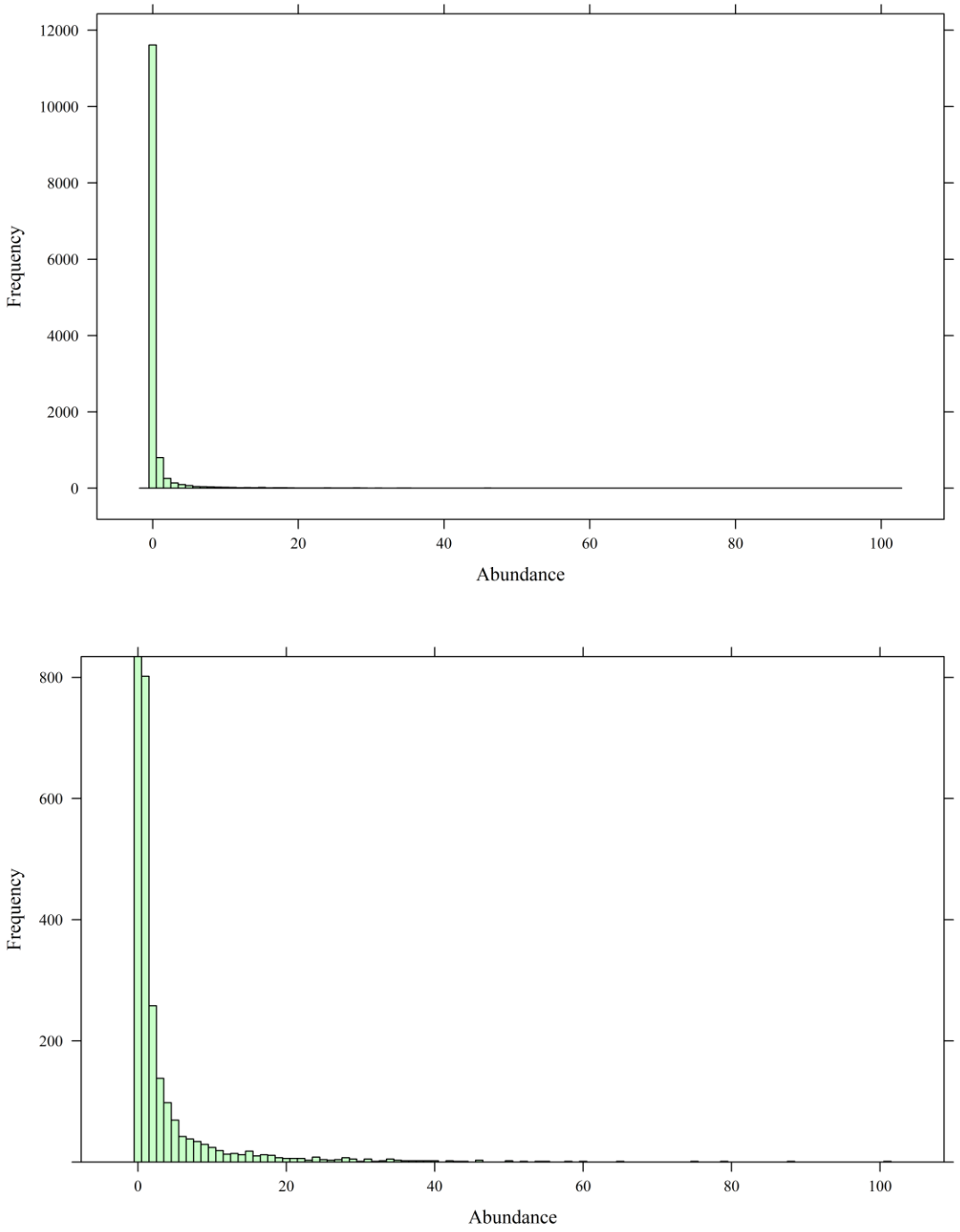

Figure 5. Count distribution of Red Snapper catch from SERFS fishery-independent chevron video trap survey showing full range of the distribution (A) and a truncated y-axis (B) to better show positive catches.

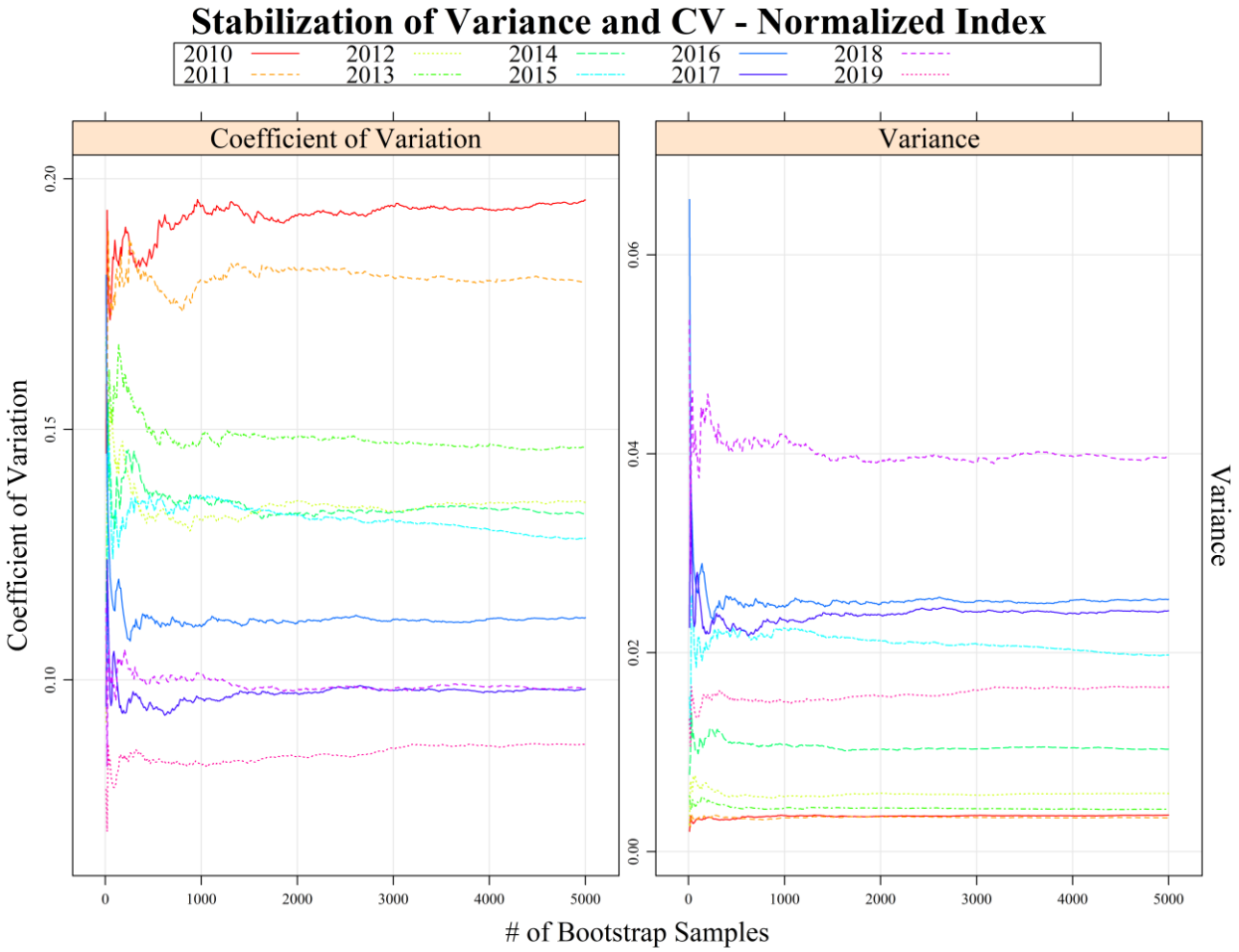

Figure 6. Stability of coefficient of variation and variance by bootstrap run during fishery-independent chevron video video trap survey index development.

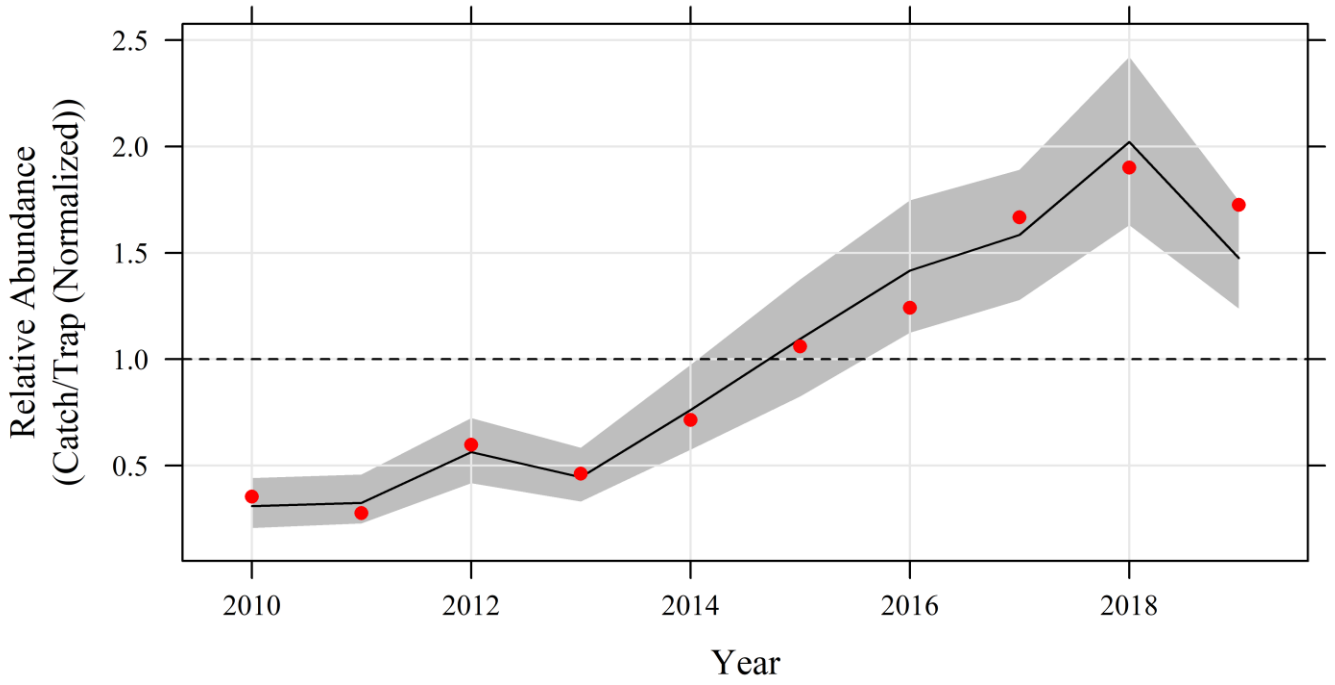

Figure 7. Normalized and standardized index (solid line) with 2.5% and 97.5% confidence intervals (gray) and the nominal index (red dots) for Red Snapper in the SERFS fishery-independent chevron video trap survey.